GLAST *the Padova group*

*The Gamma Ray Large Area Space Telescope*


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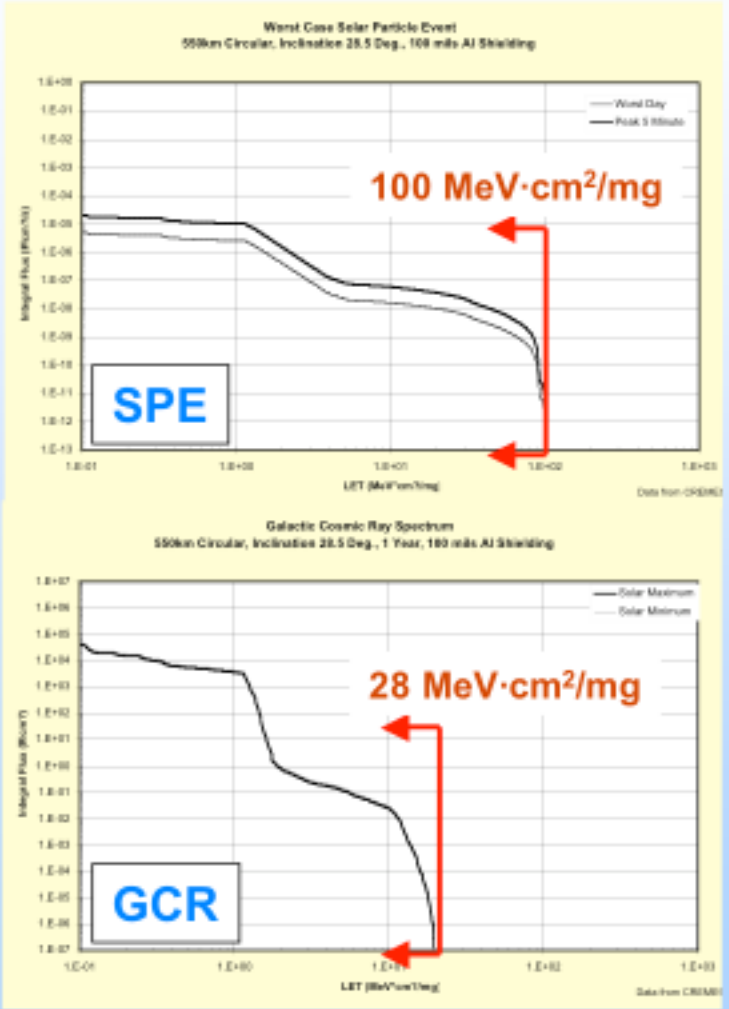
# Radiation Validation of GLAST LAT Parts

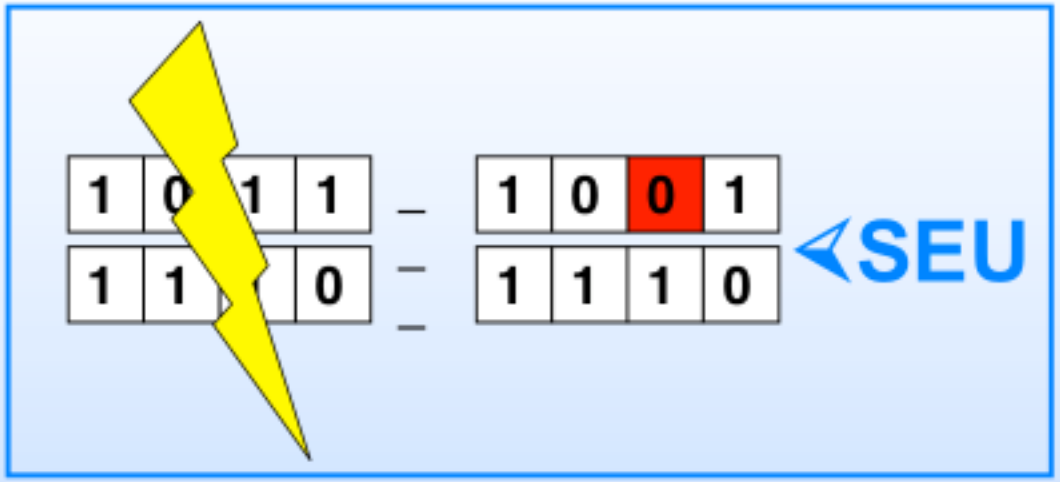
# LAT Radiation Enviroment

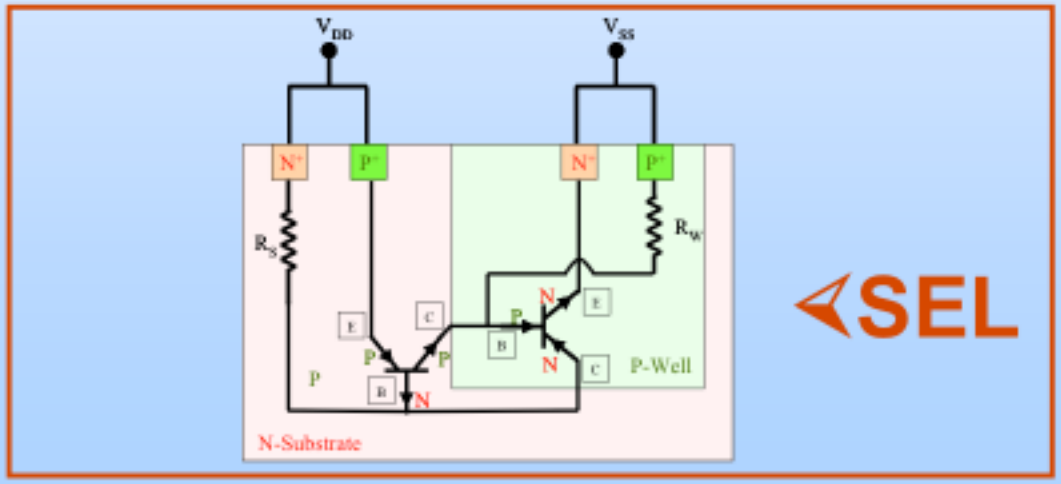
- Solar Particle Events
- Galactic Cosmic Rays
- Maximum LET
- Most interesting processes have threshold and saturation value
- Investigate performances within these two limits



# Radiation Effects: SEE (SEU+SEL)

- Expected rates are low, importance of SEE
- SEU: data corruption
- Data stored in register cells are altered by induced charge
- SEU hardened registers
- SEL: potentially destructive
- Inherent p-n-p-n in CMOS
- Can be activated by injected charge: shortcircuit
- Safety measures, but prevention is better

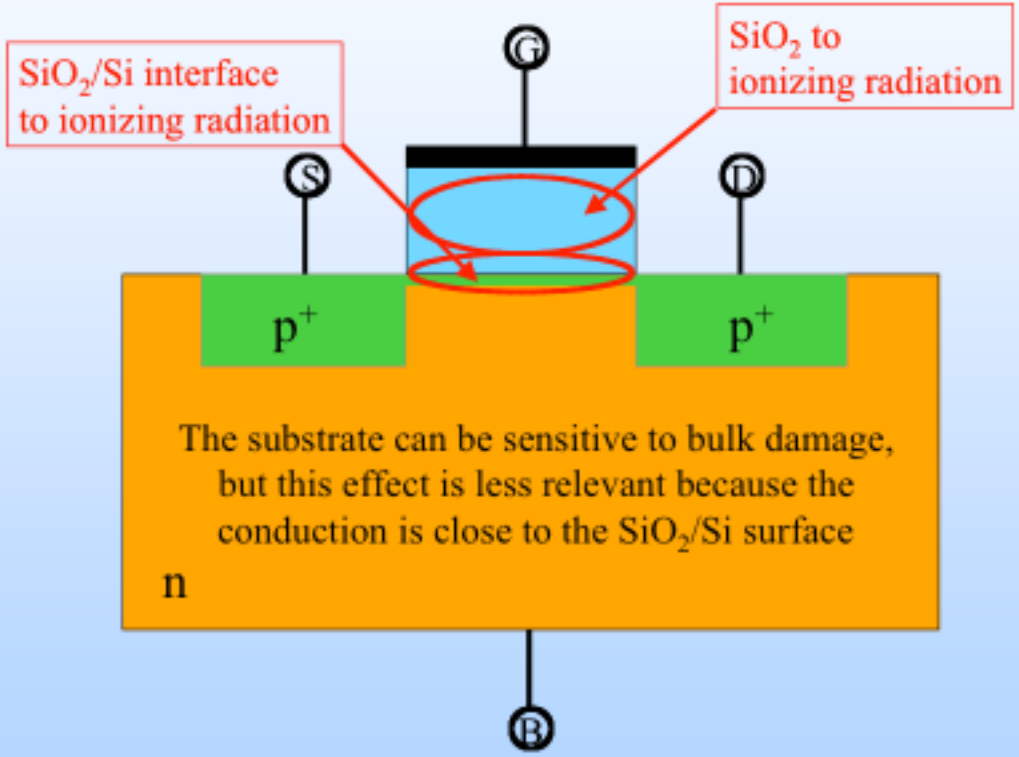


# Radiation Effects: TID

- Changes in (analogic) performances
- Damage near Si-Ox interface
- Expected dose:

  little less than 1 krad
- Monitor parameters:
  - ✓ Noise, gain
  - ✓ Threshold, ref voltages
  - ✓ Power consumption
- Does the chip survive?

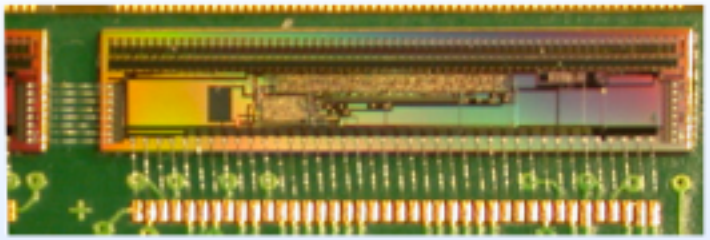


# Radiation Testing – INFN Pd

- Laboratory in Padova, testing proper at Laboratori Nazionali di Legnaro
- Collaboration started last year with LAT TKR ASICS
- Extended to include LAT DAQ, LVDS TC, DC-DC Converters…
- Many, many people involved (INFN, Padova University, SCIPP, SLAC, GSFC)

# Parts Tested

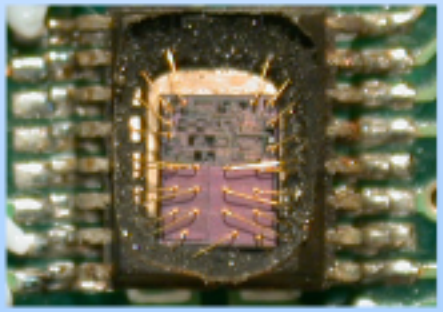
- Detailed radiation validation for LAT TKR ASICs (almost completed)
- Detailed radiation validation for LAT DAQ (50%)
- SEL validation of commercial parts (DC-DC) to be used on LAT



GTFE

GTCC
GCCC

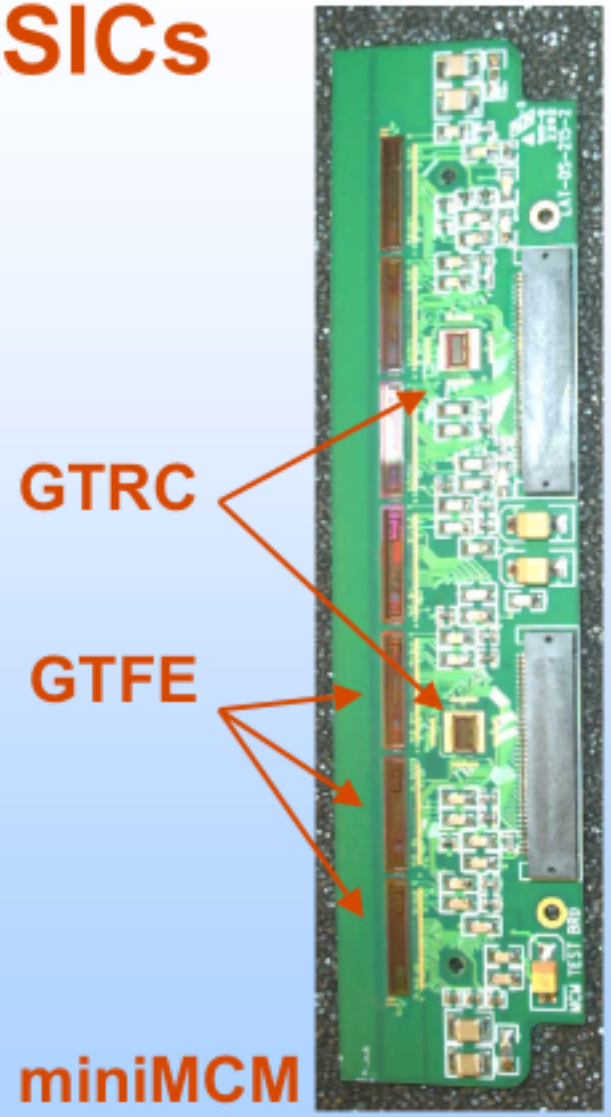
## Let's now examine a specific case: TKR



DC-DC

# LAT TKR ASICs

- Test Multi-Chip-Modules
- 7 front-end (GTFE), 64 chn's
- 2 controller (GTRC)
- 20 MHz operation
- Test SEE / TID
- To be tested: ✓ 2+2 (SEE)
  ✓ 7+7 (TID)
- SEE tests: done at LNL (Padova)
- TID tests: 4 GTRC still to do!



# TKR ASICs SEE at Legnaro (1)

- 15 MV Van de Graaf accelerator
- SIRAD beam line, for SEE/TID testing
- LET from 8 (Si) to 55 (Ag) MeV cm² / mg
- Func. Tests before irradiation
- Irradiation and test
- Look for threshold, saturation
- Calculate expected SEU in LAT TKR
- Calculate upper limit for latch-ups


Func test

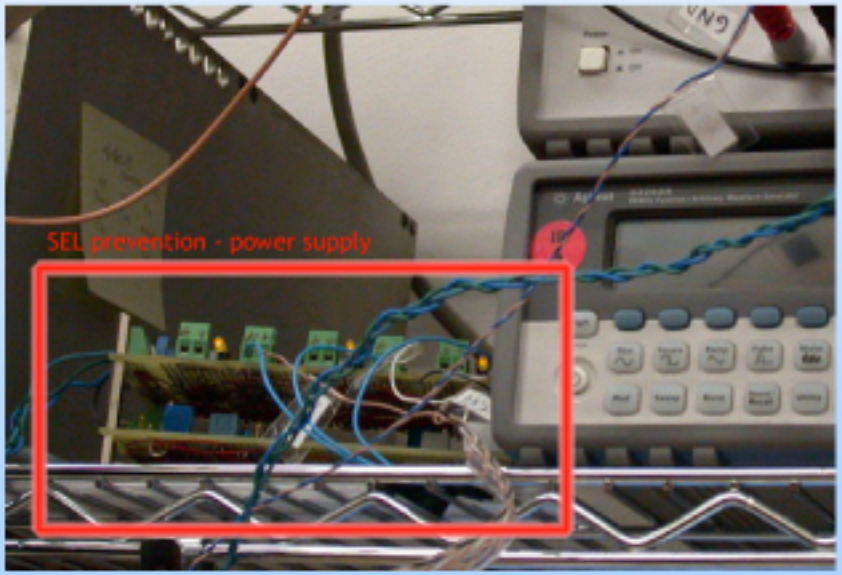
| Ion species | Energy (MeV) | LET (MeV·cm²/mg) | Range (um) | Total fluence (ions/cm²) | Dose (krad) |
|---|---|---|---|---|---|
| $^{28}$Si | 161.06 | 8.5 | 62 | $2.0\times10^{7}$ | 2.5 |
| $^{58}$Ni | 236.13 | 28.4 | 34 | $5.0\times10^{6}$ | 2.5 |
| $^{79}$Br | 246.84 | 38.8 | 31 | $4.0\times10^{6}$ | 2.5 |
| $^{107}$Ag | 271.88 | 54.7 | 28 | $3.0\times10^{6}$ | 2.5 |

Testing

# TKR ASICs SEE measurements

- Write bit patterns in registers, read back and check for errors
- Observed
  - ✓ Upsets
  - ✓ Communication Errors
  - ✓ Functionality Interrupts
- Cross sections calculated
- Power supplied by a custom-made SEL monitor power supply to prevent ASIC burnout and record latch-ups
- No latch-ups, upper limits found

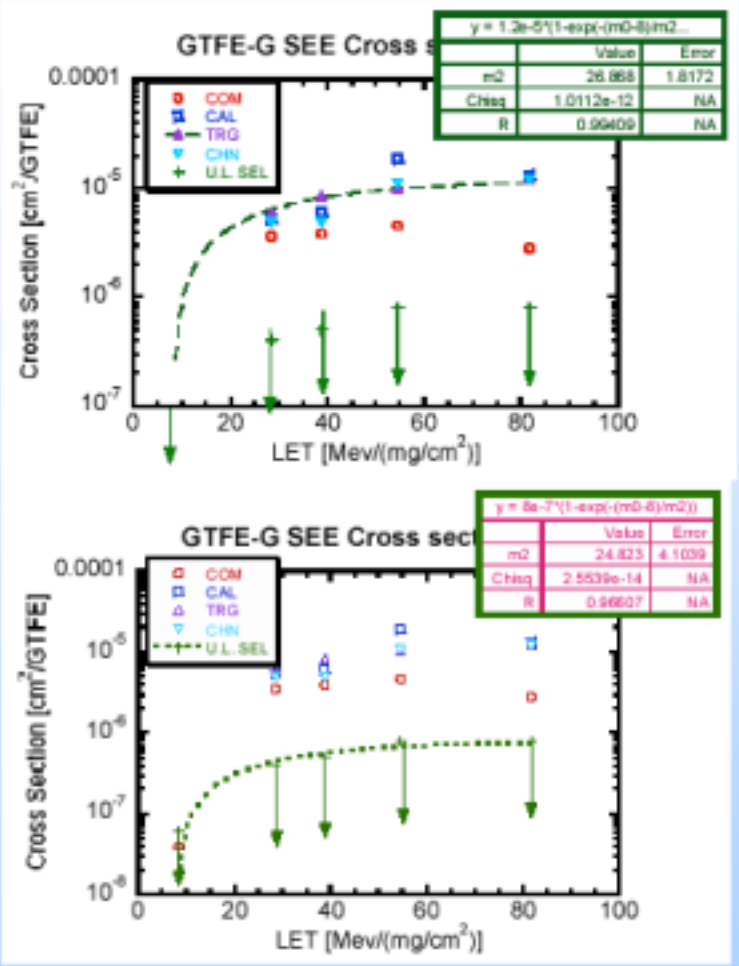
```
Thu Jun  5 15:13:57 2003
<t=271>GTFE CHN: 1 seu(s) detected!!
>>10101010101010101010101010101010101010101
<<10101010001010101010101010101010101010101
```



# TKR ASICs SEE at Legnaro (2)

- Expected upsets are few
- No latch-up : less than 3 (C.L. 95 %)
- Safest UL: maximum LET (Ag), delivered $3 \cdot 10^6/cm^2$ to both GTFE
- 5 years fluence, # of GTFE in tracker (13,824 GTFE & 1,152 GTRC)
- In the whole tracker, in 5 years upper limits and expected rates are:

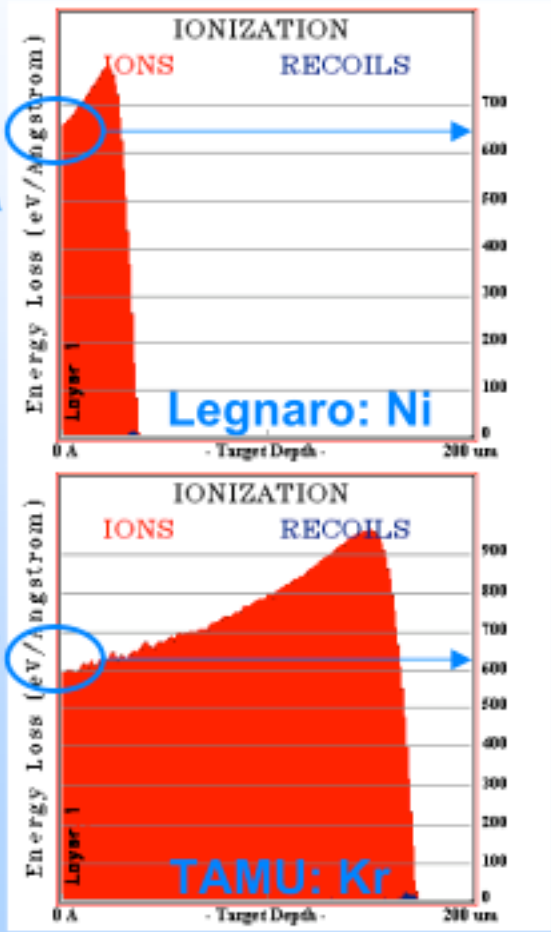
| | |
|---|---|
| ✓ SEL< $3 \cdot 10^{-3}$ | Limit |
| ✓ SEU: $2 \cdot 10^{-1}$ | Expected |
| ✓ CME: $10^{-1}$ | |
| ✓ SEFI: $2 \cdot 10^{-3}$ | |



# Interlude: SEE at TAMU (1)

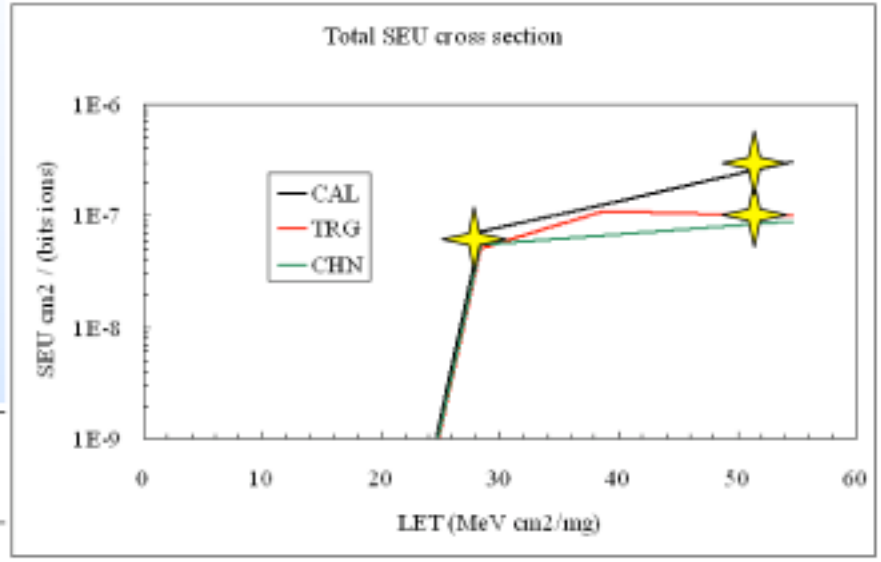
- Range at LNL limited at 60 _m
- Rumors that a greater range could show SELs
- TAMU: Cyclotron run at 15 MeV/amu:
  - ✓ Kr - LET=27.8 (LNL:Ni), r=134 _ m
  - ✓ Xe - LET=51.5 (LNL:Ag), r=120 _ m
- MCM04: SEUs (low flux for comparison)
- MCM04/03: SELs (high fluxes, high fluences)
- No latch-ups!
- Upper limit drops: ~$2 \cdot 10^{-4}$ in 5 years

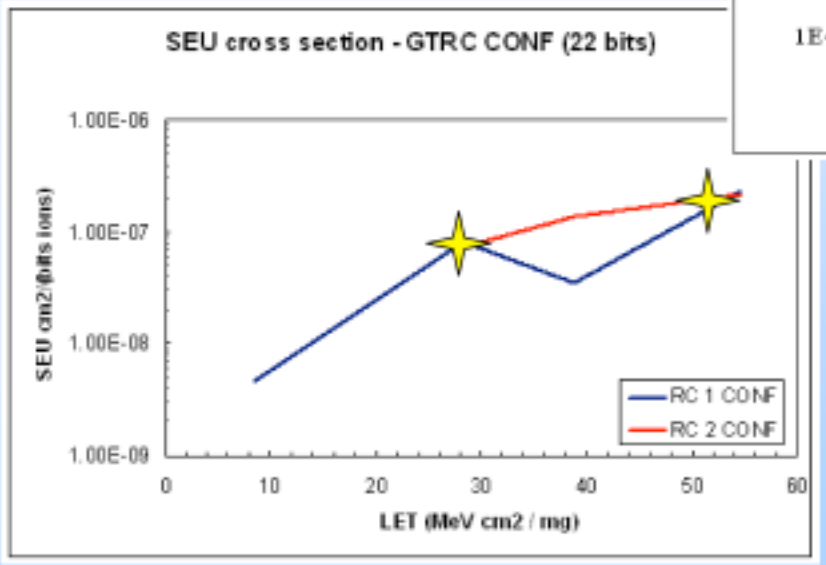
Superficial LET is ~ the same!



# Interlude: SEE at TAMU (2)

- Use low-flux runs to calculate SEU cross-sections
- Range should not matter at all
- Do they agree with what found at Legnaro?
- Yes!



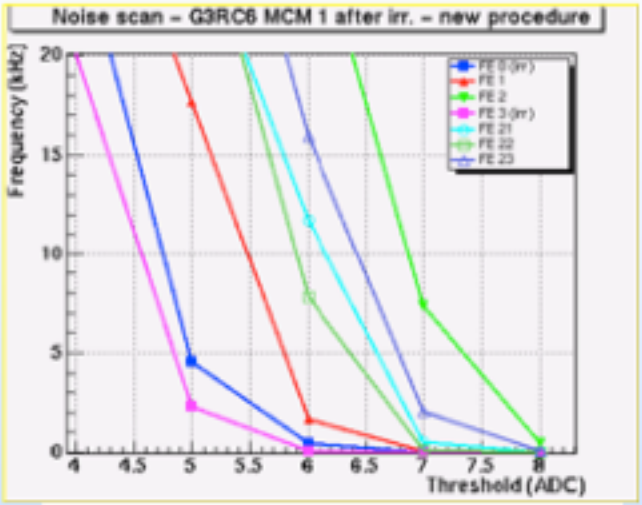



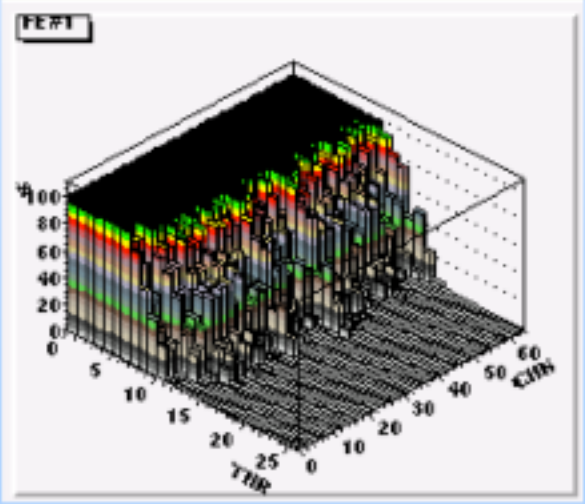

**Plots: data from LNL runs**

**= TAMU results**

# TKR ASICs TID at Legnaro

- $^{60}$Co gamma source (CNR-FRAE Padova)
- Delivered dose: 10 krad, in 4 steps
- ASICs tested after each step
- No increase in power consumption
- All ASIC functionalities OK after irradiation
- Gain OK, noise within limits
- Many ASICs tested, "by the book" (i.e. MIL-STD-883) for validation purposes, but also with ions and both ions and gamma
- Survival verified up to 40 krad!



# Conclusions

- Validation process proceeds at full speed
- More and more parts are undergoing tests
- No problem foreseen for LAT ASICs due to radiation enviroment

For all data, plots, results, look for us on the web:


and click here

**http://sirad.pd.infn.it/glast**